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TITLE: Shaped charge for blasting which does not leave a blocking slug - includes a concave liner having thick and thin walled portions, only one portion being formed of a metal with suitable jet forming properties

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PATENT-ASSIGNEE: APPLIED EXPLOSIVES TECHNOLOGY PTY LTD[EXPLN]

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ABSTRACTED-PUB-NO: AU 9859458A

BASIC-ABSTRACT:

A shaped charge comprises a cylindrical housing with a concave liner (10a) in which is packed explosive (25), the liner having thick and thin walled portions

(24,26), only one portion being formed of metal with suitable jet forming properties eg copper. The other portion is preferably formed of a metal with non-slug forming properties, eg aluminium. The liner is separately claimed.

USE - In a blasting method, especially for extracting fluids from underground (claimed); and also in military engineering.

ADVANTAGE - The charge avoids the prior art problems associated with the blocking ''slug'' or ''carrot'' in the penetration hole while achieving deep penetration.

CHOSEN-DRAWING: Dwg.4/9

TITLE-TERMS: SHAPE CHARGE BLAST LEAVE BLOCK SLUG CONCAVE LINING THICK THIN WALL PORTION ONE PORTION FORMING METAL SUIT JET FORMING PROPERTIES

DERWENT-CLASS: K03 Q79

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THIS SPECIFICATION DOES NOT CONTAIN AN ABSTRACT.

"IMPROVEMENTS IN SHAPED CHARGE LINERS"

This invention relates to improvements in shaped charges for blasting and to methods utilising same.

This invention has particular but not exclusive application to shaped charges and parts and components therefor for use in military engineering. However as will be apparent from the following the present invention can have application in civil works and exploration.

Shaped charges are known which utilise inter alia, the "Monroe Effect" in which a cavity, frequently conical, formed within a side of an explosive charge focuses the energy of the explosion into material immediately adjacent the cavity. This is illustrated diagrammatically in Fig. 1.

The penetrative effect of a shaped charge may be enhanced by lining the explosive cavity with a thin sheet formed from selected metals. The detonation of the explosive charge causes the lining material to collapse and to converge in the axis of symmetry of the charge. The liner metal is frequently copper, bronze or steel. During the detonation process, the colliding metal mass separates into relatively fast and slow moving mass portions. Only the fast moving portion with its high kinetic energy produces the perforation effect at the target. It forms a jet (or "sting") of very small diameter and correspondingly high energy. The slow moving portion (the "slug" or "carrot") is left as a molten lump after detonation. (Fig. 2).

Metals with relatively high melting points, like Copper (1083°C), Iron (1535°C) and Nickel (1453°C) and alloys of these metals perform in this manner.

Shaped charges are used in both civil and military applications for penetration of metal, concrete and geological materials. Reference may be made to "Fundamentals of Shaped Charges" Walters & Zukas - Wiley Interscience - 1988 as a useful guide to shaped charge technology.

When a large engineering shaped charge, for example the Australian and British Army Charge Demolition 30 lb. "Beehive", or the Austrian DN 50, is fired into a massive concrete, rock or metallic target, a substantial penetration cavity is produced in the target. (30 lb = 13.6 kg.) The purpose of forcing a substantial penetration cavity into these targets (ie, bridges, airfields, roadways and the like) is frequently to fill the penetration cavities with high explosives, which, when detonated, will blast a large crater for obstructing the passage of armoured vehicles or landing aircraft, or destroy bridge footings and the like, usually for the purpose of denying an enemy passage or access.

A problem frequently encountered in filling the above described penetration cavities with high explosives is that the slow moving portion ("slug" or "carrot") of the shaped charge liner is left as a molten lump and can and frequently does effectively block the penetration hole, typically about two thirds of the way up the hole, and is usually

irremovable, as the "slug" is firmly extruded into the sides of the penetration hole.

For example, a 30 lb Beehive charge will typically penetrate 1800 mm into hard reinforced concrete, but the "slug" which is practically or effectively irremovable, obstructs the jet penetration hole about 600 mm from the top of the hole (Fig. 3).

The effect is that only the outer portion of the hole can be filled with explosives, with the result that a relatively small crater or destructive effect is produced on detonation of the explosives. If the "slug" was not blocking the cavity, more explosives could be placed deeper into the target, which, when detonated, would provide much greater cratering and/or destruction of the target.

Shaped charge liners have been fabricated of glass or ceramic material as an attempt to overcome this difficulty. These materials form a finely particulated "sting" and "slug" when exposed to detonation forces, and thus do not generally block penetration cavities in targets as described above. The penetration depths of cavities resulting from these materials as shaped charge liners are not as great as those depths of cavities produced by metal liners, particularly copper, which is the most frequently used metal for this purpose.

Typically, depths of cavities obtained by using non-metallic liners are half to two thirds as deep as those

cavities produced by use of metallic, particularly copper, liners. This is because the jet density and coherency is less and is more easily attenuated than a jet of metal, particularly copper.

It is well known in the art that certain metals do not form "slugs' when they are used as shaped charge liners. These metals are those with a relatively low melting point, such as zinc (419.5°C) cadmium (321°C), lead (327°C) aluminium (660°C) and the like.

It is further understood in the art that, in use, the liner collapses along its central axis when the explosive detonation wave passes along the interior surface and that only a small portion of the total mass of the liner is formed into the jet, the rest forming the relatively slow moving and obstructive "slug".

This invention aims to alleviate the disadvantages associated with the blocking "slug" or "carrot" in the penetration hole and to provide shaped charges which effect relatively deep penetration effects.

With the foregoing in view, this invention in one aspect resides broadly in a shaped charge of the type including a cylindrical or frustoconical housing supporting a concave liner, explosive material packed within said housing about said concave liner, wherein said liner is formed from a composite material having:

a relatively thick walled portion;

a relatively thin walled portion in layered relationship with said relatively thick walled portion, and wherein

only one of said relatively thick walled portion or said relatively thin walled portion is formed of metal with suitable jet forming properties.

Preferably, the relatively thick walled portion is formed of a material with non-slug forming properties and said relatively thin walled portion is formed from a metal with suitable jet forming properties. The layered relationship of the relatively thin and thick walled portions is one of intimate contact as any air gaps between the layers causes catastrophic perturbations in the jet.

The material with the non-slug forming properties is selected from glass, ceramic material, and/or metals with a relatively low melting point and such like. Preferably, the relatively thin wall portion is formed of a metal with a relatively high melting point, such as copper, iron, nickel or such like and alloys of such metals. It is also preferred that the relatively thick walled portion is disposed closest to the explosive. The relatively thin walled portion thus suitably forms a metal exterior of the conical liner and is preferably formed of a metal with a relatively high melting point as described above.

Preferably the relatively thick walled portion is formed of a material with non-slug forming properties such as glass or ceramic material or metals with a relatively low melting

point, such as zinc, cadmium, lead. However the preferred material is aluminium deposited onto the relatively thin liner portion and which may or may not be machined after deposition.

Preferably the relatively thin walled portion is a metal wall portion with suitable jet forming properties. However the reverse arrangement may be utilised if the combination of liner materials results in a charge having good penetration effects which does not leave a blocking "slug" or "carrot" in the penetration hole.

The concave liner may be any concave shape such as a dome or hemisphere. Preferably, the relatively thin wall portion is conical and formed to a thickness between 0.2% to 2.5% of the charge diameter, and said relatively thick walled portion is formed to a thickness between 1.5% to 5% of the charge diameter. The cone angle is preferably between 40° and 120°, and more preferably 60°.

In another aspect, this invention resides broadly in a liner for a shaped charge as hereinbefore described. Preferably, the liner has the relatively thin wall portion made from copper and the relatively thick wall portion made from aluminium deposited onto the relatively thin wall portion.

This exterior surface metal may be fabricated by spinning, shear forming, multiple step pressing, or any other suitable method. The preferred methods of this invention are

spinning or shear forming, both well known in metal forming art. The shape of the liner may be any suitable symmetrical shape, such as a cone, a pyramid, a truncated cone or pyramid, or a stepped cone or pyramid, or a portion of an obloid or parabolic body. However the preferred shape according to this invention is conical, although a variety of other shapes as above are possible and practical.

The overlay, or relatively thick wall portion as described above is suitably formed of aluminum, which may be deposited onto the interior face of the external surface metal liner, conveniently by means of wire arc spray or high velocity oxygen fuel (HVOF) deposition or other suitable metal deposition technique as is known in metal deposition art. The external relatively thin liner as described above may require preparation by grit or garnet blasting and an arc spray of a preparatory alloy to receive the overlay material. Furthermore by use of spray fusion or HVOF the overlay may be of a ceramic, cermet (mixture of metal and ceramic) or metal carbide.

The proportions of and the makeup of the relative thin and thick materials may be tailored to alter and enhance the performance of jet penetration in massive targets.

In another aspect, this invention resides broadly in a method of blasting including forming a penetrating a cavity in a body using a shaped charge having a liner as hereinbefore described, and placing and detonating explosives

in the penetrating cavity so formed.

That is by use of the improved shaped charge liner in the construction of engineering shaped charges as described above, a more useful penetration tunnel, ie one that is capable of holding more explosives that when detonated make a more profound crater or produce more damage to structures intended for demolition than has been possible using the prior art shaped charge liners in the construction of shaped charges.

In yet another aspect, this invention resides broadly in a method of extraction fluids from an underground supply, the method including forming a penetrating cavity in the body in which the fluid to be recovered is contained using a shaped charge having a liner as hereinbefore described, and placing and detonating further shaped charges or other explosive in the penetrating cavity so formed so as to extend the cavity into the body to form a unobstructed tunnel through the body towards the fluid to be extracted.

Suitably, the shaped charge of the present invention is placed in the bottom portion of a well, such as an oil well shaft, and detonated to provide an elongate cavity for the well to be completed. Preferably, a plurality of shaped charges of the present invention are used to provide good flow into the bottom of the well shaft and subsequently out of the well.

In order that this invention may be more readily

understood and put into practical effect, reference will now be made to the following examples which illustrate a preferred embodiment of this invention and its intended effect.

EXAMPLE 1

A shaped charge was prepared having a conical base portion. The base portion was formed from 46 g of copper having a thickness of 0.84 mm, and having deposited thereon aluminium to a total wall thickness of 2.0 mm. The total mass of the liner was 86 g. The charge casing, cap, and liner assembly had a mass of 266 g, and had a maximum diameter of 75.58 mm to 75.66 mm. When filled with plastic explosive, the gross mass of the shaped charge was 1.022 kg.

The shaped charge so formed was placed on a steel billet test target, and fired with a standard L2A1 detonator.

After firing, the billet was found to have a crater with a volume of 50 ml, which penetrated the full thickness of the billet, that is, a depth of 300 mm. The impact diameter of the crater was 39.5 mm and the diameter of the crater at full depth was 11 mm. There was found to be no slug formation in the crater created by this test.

EXAMPLE 2

A shaped charge was prepared having a conical base portion. The base portion was formed from 46 g of copper having a thickness of 0.84 mm, and having deposited thereon aluminium to a total wall thickness of 2.0 mm. The total

mass of the liner was 86 g. The charge casing, cap, and liner assembly had a mass of 264 g, and had a maximum diameter of 75.72 mm to 75.86 mm. When filled with plastic explosive, the gross mass of the shaped charge was 1.039 kg.

The shaped charge so formed was placed on a 350 mm thick steel billet test target, and fired with a standard L2A1 detonator.

After firing, the billet was found to have a crater with a volume of 60 ml, and a full depth of 316 mm. The impact diameter of the crater was 37.0 mm and the diameter of the crater at full depth was 11 mm. There was found to be no slug formation in the crater created by this test.

In order that this invention may be more readily understood and put into practical effect, reference will now be made to the accompanying drawings which illustrate prior art teachings and a preferred embodiment of this invention and its intended effect, and wherein:-

Fig. 1 illustrates the cross section of a conventional shaped charge;

Fig. 2 shows a schematic representation of the effect of explosion of the charge of Fig. 1;

Fig. 3 is a cross-section illustrating the penetrating effect of a prior art shaped charge;

Fig. 4 illustrates the cross-section of a shaped charge according to this invention;

Fig. 5 shows the exemplary liner in process of

deformation;

Fig. 6 illustrates the cross-section of the jet penetration desired to be made by the present invention;

Fig. 7 illustrates in cross-sectional view a shaped charge in accordance with a preferred embodiment of the invention, and

Figs. 8 and 9 illustrate in cross-sectional view respective craters produced by the test firings described in respect of examples 1 and 2 above respectively.

Referring to the drawings it will be seen that a conventional shaped charge 9 is cylindrical and has a conical liner 10 with an external surface 12 and an internal surface 11 against the explosive 13 which fills the casing 16. A booster 14 and detonator 15 for the explosive charge are supported in the casing 16.

As illustrated in Fig. 2, detonation of the explosive 20 surround the internal surface of the conical liner 19, which typically has a thickness of about three percent of the overall diameter of the housing 16, forms a fast moving penetrating jet 17 and a relative slow moving slug 18, which, as illustrated in Fig. 3 can result in deep jet penetration 21 into a solid body 22, such as reinforced concrete, with the slug 23 obstructing the penetration 21. Thus only the top portion of the hole formed by the penetration 21 can accommodate further blasting explosives.

Referring to Fig. 4 it will be seen that the illustrated conical shaped charge liner 10a is formed as a composite of copper and aluminium, with a the relatively thick internal layer 24 formed of aluminium layer in contact with the explosive material 25 and the thin copper layer forming the external surface 26 of the liner.

In the process of deformation, as illustrated in Fig. 5, it is believed that the copper external layer 27 will form the jet tip 28 for penetrating a reinforced concrete body 33, for example, and the trailing portion of the jet 29, which will include the aluminium layer 30, will be deposited about the walls 37 of the jet penetration tunnel 34 without obstructing the tunnel, such as is illustrated at 35.

Referring to Fig. 7, a shaped charge 40 includes a cap detonator well 41 atop a plastic charge casing 42. Explosive fill 43 is shown cross-hatched, and is contained by the charge casing 42 and supported by a conical liner 44 having a spheriform apex 45.

It is believed that the exterior surface as described above can be fabricated of a very thin layer of a metal such as copper. If on this metal is laid another metal, for example aluminium, and the aluminium overlay is then placed in contact with the explosive material, then when the explosive is detonated; the resulting jet will be primarily of copper or copper/aluminium which will be completely melted, vaporised and ablated by the high temperatures

generated during jet penetration. The slug or relatively slow moving portion of the liner will melt and be formed predominantly of aluminium which will adhere to the sidewalls of the penetration cavity. Thus this slow moving portion will not form a complete obstruction to the lower parts of the cavity and will exist as a thin layer of metal coating the walls of the cavity.

Furthermore, it is considered that the jet penetration will be almost as profound as if the liner were fabricated in its entirety of copper.

It will of course be realised that while the above has been given by way of illustrate example of this invention, all such and other modifications thereto as would be apparent to persons skilled in the art are deemed to fall within the broad scope and ambit of this invention as claimed in the following claims.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A shaped charge of the type including a cylindrical housing supporting a concave liner, explosive material packed within said housing about said concave liner, wherein said liner is formed from a composite material having:

a relatively thick walled portion;

a relatively thin walled portion in layered relationship with said relatively thick walled portion, and wherein

only one of said relatively thick walled portion or said relatively thin walled portion is formed of metal with suitable jet forming properties.

2. A shaped charge as claimed in claim 1, wherein said relatively thick walled portion is formed of a material with non-slug forming properties and said relatively thin walled portion is formed from a metal with suitable jet forming properties.

3. A shaped charge as claimed in claim 2, wherein said material is selected from glass, ceramic material, and metals with a relatively low melting point.

4. A shaped charge as claimed in any one of the preceding claims, wherein said relatively thin wall portion is formed of a metal with a relatively high melting point.

5. A shaped charge as claimed in claim 4, wherein said metal is selected from copper, iron, nickel and alloys of such metals.

6. A shaped charge as claimed in any one of the preceding claims, wherein said relatively thick walled portion is disposed closest to said explosive.

7. A shaped charge as claimed in any one of the preceding claims, wherein said relatively thin wall portion is conical and formed to a thickness between 0.2% to 2.5% of the charge diameter, and said relatively thick walled portion is formed to a thickness between 1.5% to 5% of the charge diameter.

8. A liner for a shaped charge as claimed in any one of the preceding claims.

9. A liner as claimed in claim 8, wherein said relatively thin wall portion is copper and said relatively thick wall portion is aluminium deposited onto the relatively thin wall portion.

10. A method of blasting including forming a penetrating a cavity in a body using a shaped charge having a liner as claimed in claim 8 or claim 9, and placing and detonating explosives in the penetrating cavity so formed.

11. A method of extracting fluids from an underground supply, the method including forming a penetrating cavity in the body in which the fluid to be recovered is contained using a shaped charge having a liner as claimed in claim 8 or claim 9, and placing and detonating further shaped charges or other explosive in the penetrating cavity so formed so as to extend the cavity into the body to form a unobstructed tunnel through the body towards the fluid to be extracted.

12. A shaped charge substantially as herein described in any one of the examples with reference to the drawings.

DATED THIS NINTH DAY OF OCTOBER 2001

APPLIED EXPLOSIVES TECHNOLOGY PTY LTD

BY

PIZZEYS PATENT AND TRADE MARK ATTORNEYS

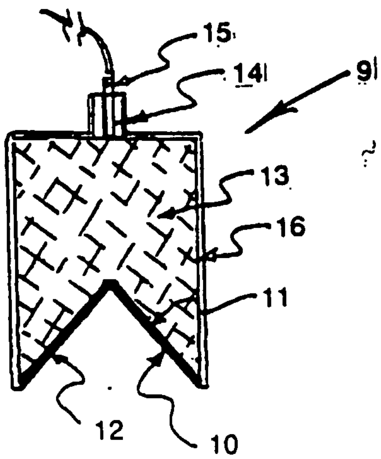

Fig. 1

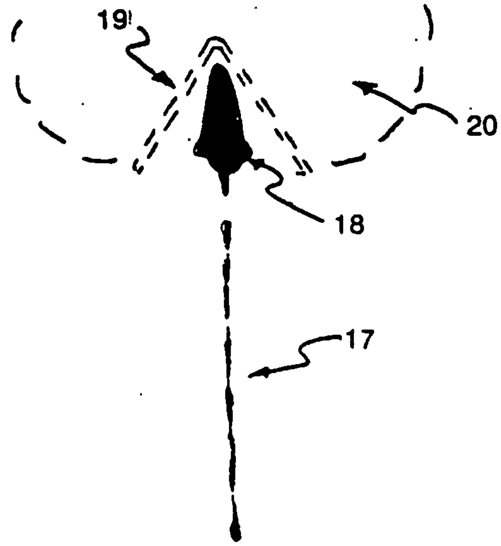

Fig. 2

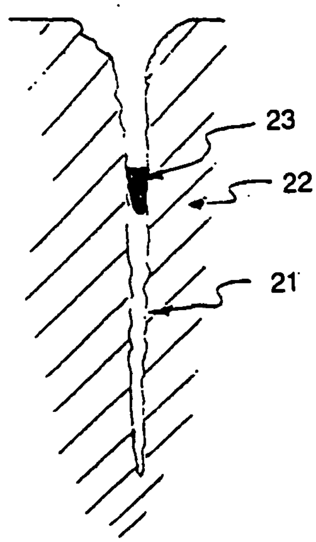

Fig. 3

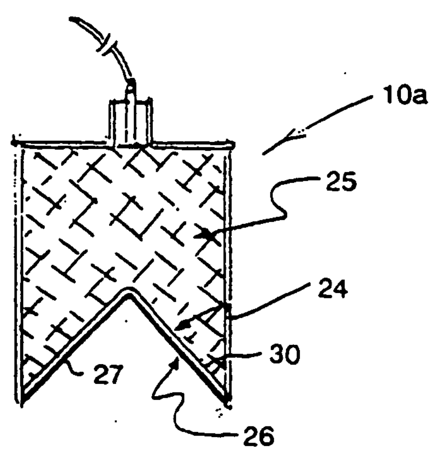

Fig. 4

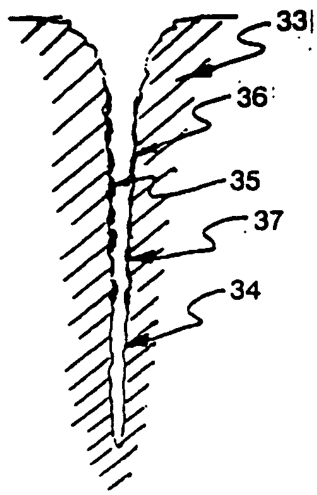

Fig. 6

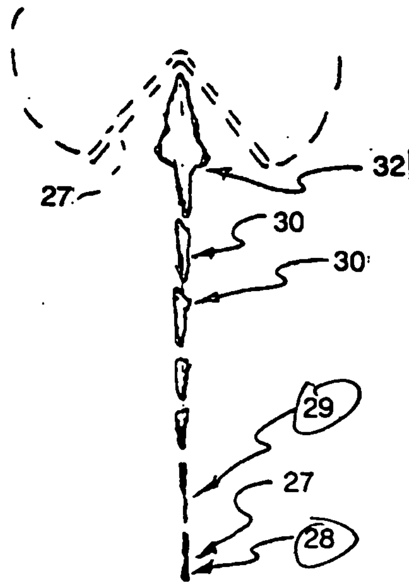

Fig. 5

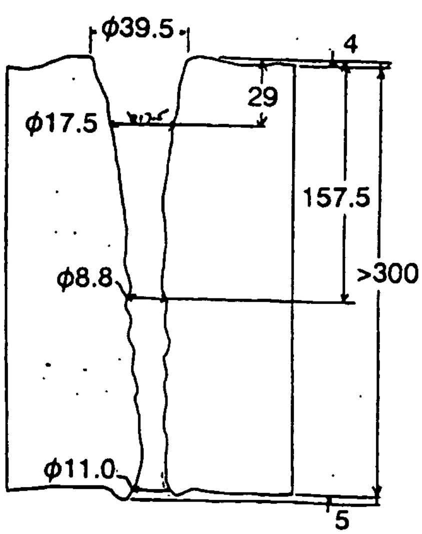

Fig. 8

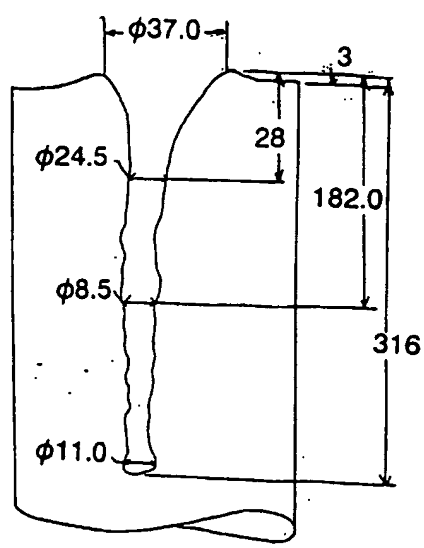

Fig. 9

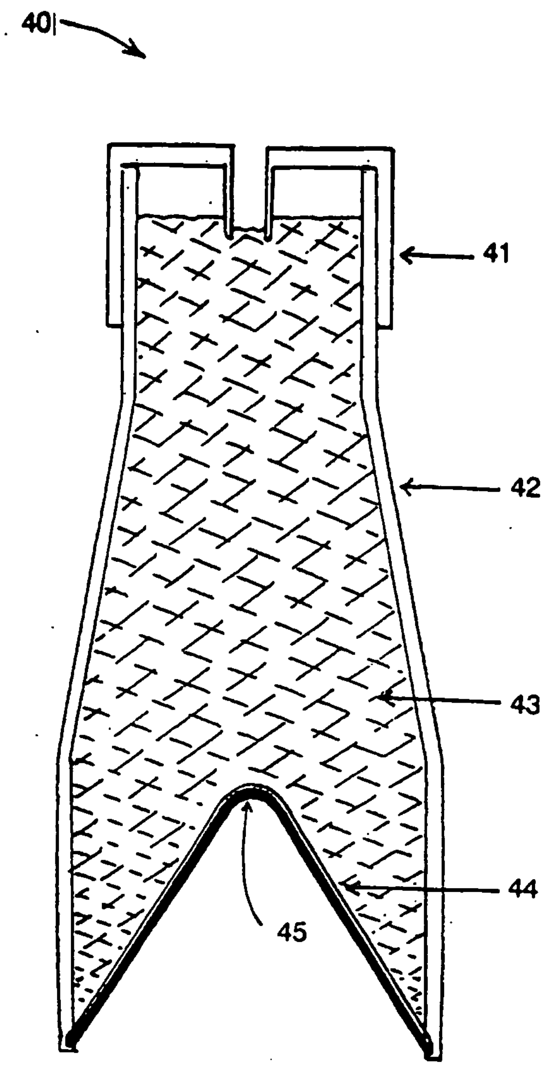

Fig. 7